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(54) **A video processing system for stored video frame sequence**

(57) A video processing system comprising a processing unit 12 a VDU 16 and a look-up table 17. A user defined profile is displayable on the VDU 16 and can be adjusted interactively by way of a stylus 14 and touch tablet 15. Data representing the profile is stored in the look-up table. An input video clip is stored in digital form in a disc store 10 and output video clip frames are generated in accordance with the user defined profile data. The system can be used for example to stretch or compress a video clip in time.
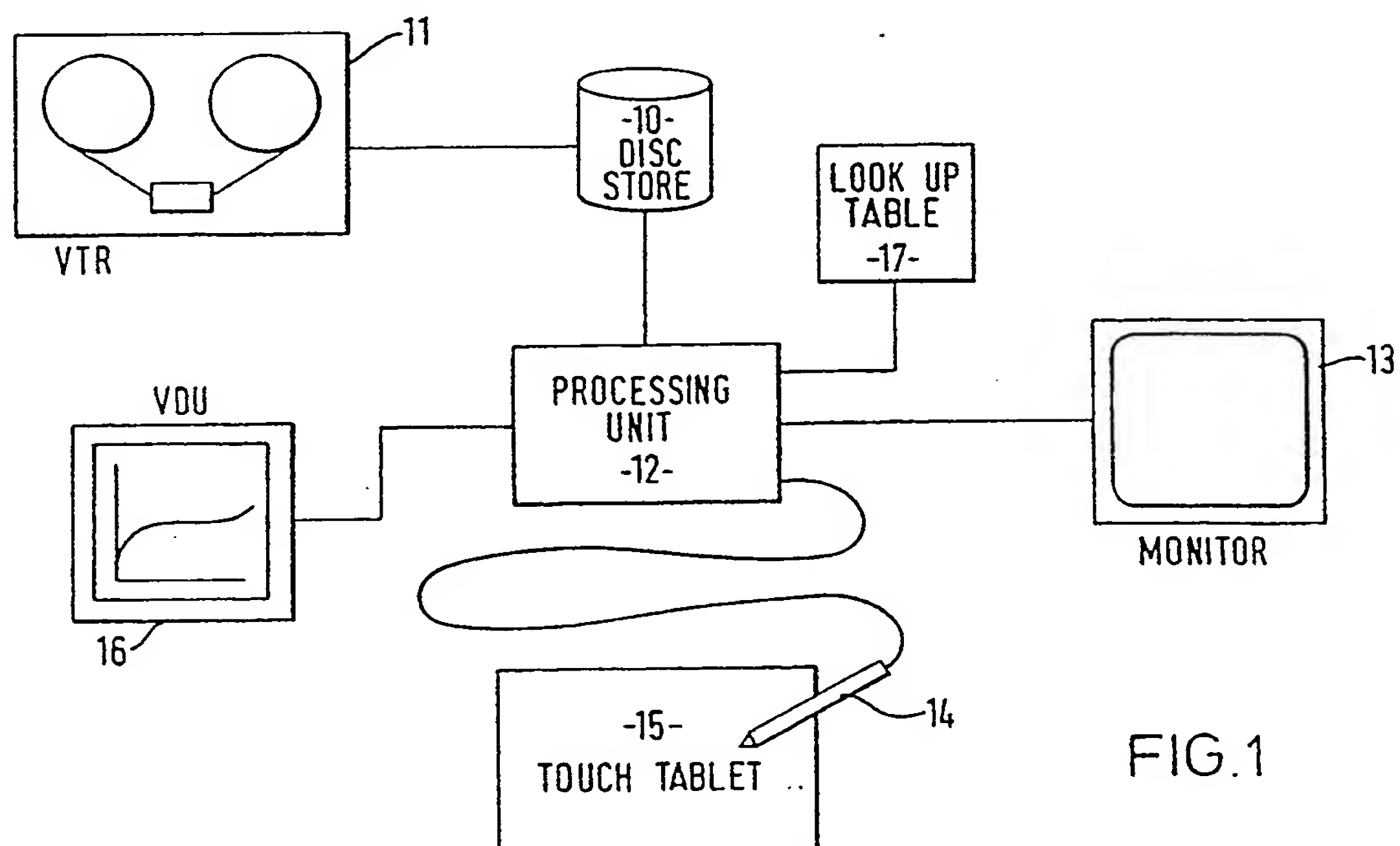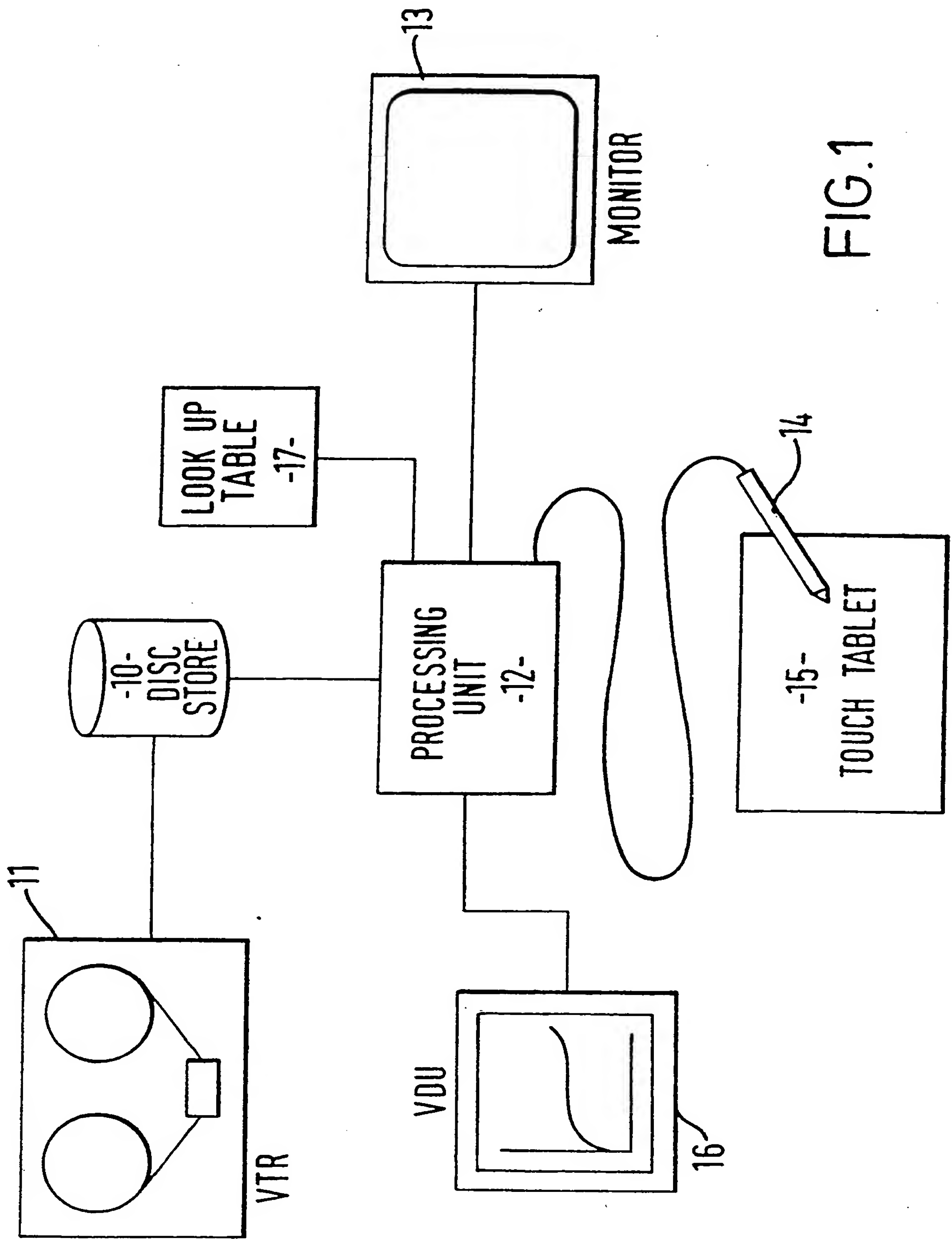

FIG.1

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.
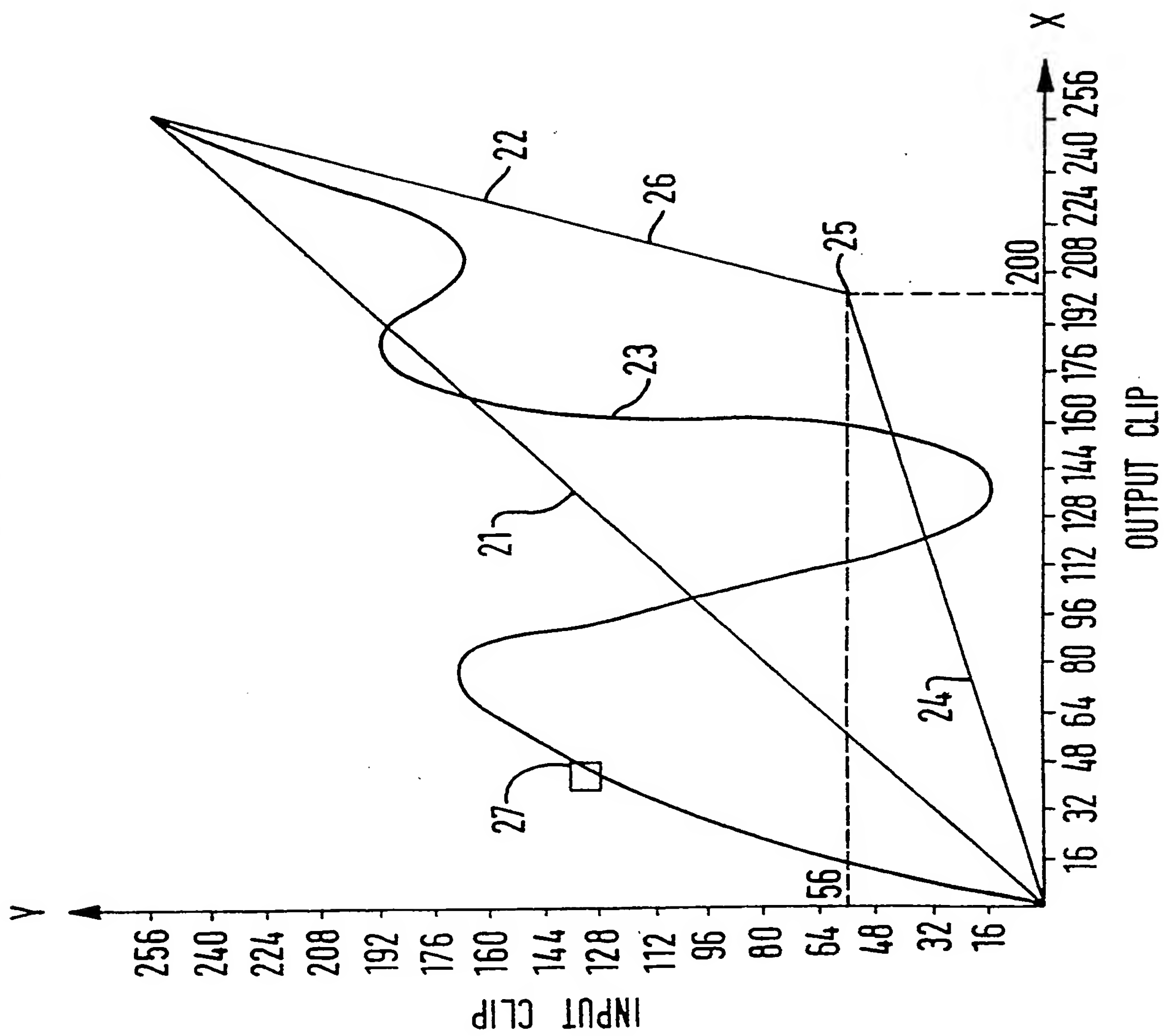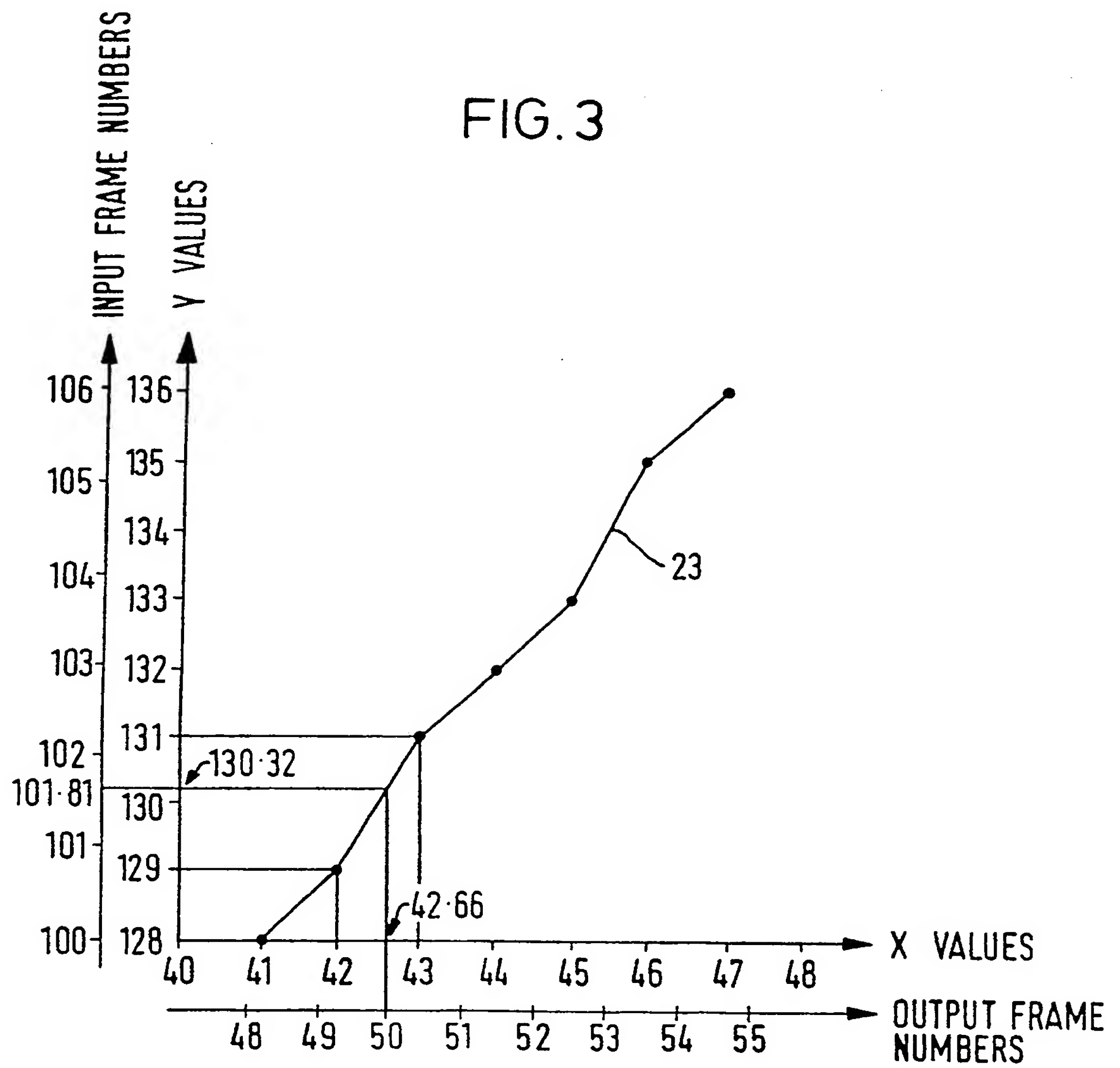
FIG.1

FIG.2

FIG.3

A VIDEO PROCESSING SYSTEM

FIELD OF THE INVENTION

The invention relates to a video processing system and in particular relates to a system in which
5   an input sequence of video frames is processed to produce an output sequence.

BACKGROUND OF THE INVENTION

Editing techniques are known in which the normal sequence of video frames from a video clip is altered
10   to produce a re-timed sequence. For example a clip having a duration of only a few seconds may be repeated or individual frames of a clip may be removed to reduce slightly the duration of the clip. These techniques are often employed to synchronise video to
15   an audio soundtrack and in more sophisticated applications for example to synchronise the movements of a mouth (possibly that of an animal) to a recorded soundtrack, of say, speech. The legs of an animal may also be synchronised in this way so that a single leg
20   movement may be repeated many times to create, say, the illusion of a cow 'dancing' in time to recorded music.

A machine which has made these effects, and many more, available to commercial video producers is
25   manufactured by the present Applicant and sold under the trademark "HARRY". In this machine, frames of video are digitally encoded and stored on magnetic discs, as disclosed in US Patent No. 4,688,106 assigned to the present applicant. A problem with
30   known techniques for stretching video clips is that each stretching (or compressing) process has been limited to very simple functions, such as stretch by 20%, or remove 3 frames etc. Thus, a complicated movement lasting only a few seconds may have to be

built up from many small clips having different functions applied thereto.

OBJECTS AND STATEMENTS OF THE INVENTION

The invention aims to provide an improved system for stretching and compressing video clips.

According to the present invention, there is provided a video processing system, comprising a video storage device for storing an input sequence of video frames; defining means for defining an output sequence of video frames in relation to said input sequence frames; and generating means for generating an output sequence of video frames from said input video frames in accordance with the defined relationship.

The above and further features of the invention are set forth with particularity in the appended claims and together with advantages thereof will become clearer from consideration of the following detailed description of an exemplary embodiment of the invention given with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a video processing system including a graphical device for displaying functional profiles;

Figure 2 shows examples of graphical profiles of the type displayed on the device shown in Figure 1; and

Figure 3 shows an enlarged portion of a profile shown in Figure 2.

DETAILED DESCRIPTION OF AN EMBODIMENT OF THE INVENTION

A video processing system is shown in Figure 1 in which an input sequence of video frames, referred to herein as an input clip, is supplied to a parallel magnetic disc store 10 from a video tape recorder VTR 11. The video data is stored on disc as digitally

encoded pixels, each having components representing luminance and two colour difference values. A system for storing video data on magnetic disc, allowing data transfer at video rate, is disclosed in United States
5   Patent No. 4,688,016 assigned to the present Applicant. Alternatively, the data may be stored in a solid-state memory device. Preferably, the video data is in the abovementioned component form but a D2 composite machine, or an analogue machine, may instead
10   be used together with a suitable converting device for converting the data into component form.

       Data from the disc store 10 is read by a processing unit 12. The processing unit 12 is arranged to convert the video data from its component
15   form into analogue signals which are applied to a monitor 13 for display of the video image on the monitor 13. The monitor 13 is arranged also to display symbols representing user selectable control functions in the form of a menu of options from which
20   a function can be selected. A stylus 14 and a touch tablet 15 are provided in order to facilitate control of the system. Positioning and movement of the stylus 14 on the touch tablet 15 causes the touch tablet 15 to generate signals representative of the position of
25   the stylus 14 and these signals are interpreted by the processing unit 12 to cause a cursor (not shown) to be displayed at a corresponding position on the monitor 13. The stylus 13 is pressure sensitive and values representing the pressure applied by the stylus to the
30   touch tablet 14 are also delivered to the processing unit 12. In order to select an option from the menu, the cursor is moved over the representation in the menu of the desired option by way of movement of the stylus on the touch tablet and the pressure applied by
35   the stylus is increased by pressing down hard. The

processing unit 12 responds to this by reconfiguring the system to perform the selected function.

A function which can be selected, from the menu displayed on the monitor 13, is "profile stretch" in which an input video clip is stretched, compressed or reversed in response to a profile defined by the user of the system. When "profile stretch" is selected the processing unit 13 causes a visual display unit. VDU 16 to display a profile graph defined by mutually perpendicular x and y axes, in which the vertical y axis represents the frames of a stored input video clip and the horizontal x axis represents the frames of a video clip to be generated and output for display.

The profile graph displayed on the VDU 16 is shown in detail in Figure 2 of the accompanying drawings. Figure 2 also shows three exemplary user defined profiles 21, 22 and 23. A profile defining the relationship between input video frames and output video frames can be defined by the user by way of operation of the stylus 14 upon the touch tablet 15, with movement of the stylus being interpreted by the processor 12 as corresponding changes in the profile. The definition of the profile graph on the VDU 16 is preferably 256 x 256 points and therefore a profile will consist of lines connecting points on a 256 x 256 grid. Other grid definitions may be used but the 256 grid is suitable for most applications. As a profile line is drawn the position of the stylus along the y axis is stored for each of the 256 positions along the x axis - the y scale also being divided into 256 positions.

Of the three profiles shown in Figure 2, the profile 21 ($y = x$) produces no effect because the number of each output video clip frame corresponds to

the number of each input video clip frame. The profile 21 is therefore an identify function.

The profile 22 comprises a first portion 23 and a second portion 24 connected at a knee point 25. The first portion 23 causes a first portion of an input video clip comprising a number of frames to be stretched over a larger number of output frames, so that on playback the first portion frames of the clip are displayed on the monitor at a slower rate. After the knee point 25, the remaining frames of the input video clip are compressed in time for display in the remainder of the output clip. The remaining frames are therefore seen at increased speed.

The profile 23 first causes a portion of the clip to be output at a faster rate, it then causes the output clip to be the reverse of the input clip for a while, it next causes a portion of the output clip to be an even faster version of a corresponding portion of the input clip, for a short period a portion of the output clip is again the reverse of a corresponding input clip portion, and finally the last few frames at the output clip are a speeded up version of the corresponding last few input clip frames. Each of the profiles 21 to 23 shown produces an output which starts at the first frame of the input clip and ends at the last frame of the input clip. However a profile does not necessarily have to conform to this constraint and a profile may be drawn anywhere within the area bounded by the axes, subject to the restriction that the input frames (y) must be defined as a continuous function of output frames (x) with only one value of y for each value of x.

An input clip may consist of any number of input video frames and similarly an output clip may be defined as any number of output video frames; the number of

input frames being defined when the clip is selected and the number of output frames being selected by the operator. The scale of the profile graph is for example 256 by 256 points and the profile is stored by

5 programming a look-up table 17. The look-up table 17 consists of a random access memory device having 256 memory locations one for each x axis value and each location being arranged to store an eight bit code representing a corresponding y axis value as defined

10 by the profile. Memory locations are addressed by supplying an 8 bit address code corresponding to an x axis value. That is to say, an eight bit code representing a value on the x axis is applied to the address bus of the memory device to produce at the

15 memory output an eight bit code representing a value on the y axis.

A profile is defined by use of the stylus 14 and the touch tablet 15. Points can be defined at any desired position on the graph and when a point is

20 selected, the x value at that point is used to address a location in the look-up table 17 and the corresponding y value is stored as an eight bit code at that location. When a point is defined by the user, the profile between the defined point and the

25 previously define point is displayed by drawing a straight line (i.e. by linear interpolation) between the two points. With all desired points in the profile selected, the profile may be smoothed between points by applying a smoothing function, for example

30 least squared fit, to the selected points. Predefined profiles such as a sinewave portion or other commonly used functions can also be stored in memory and selected by the user when required, instead of having to define a profile each time the "profile stretch" is

35 to be used. Once the profile has been defined, an

input clip is identified from the video data in the disc store 10 using the stylus and touch tablet interactively with the monitor 13. This interactive identification consists of the user identifying the

5 desired start frame and end frame of the input clip from the available video in the disc store 10, thereby defining the number of frames in the input clip. The number of output frames is then selected and a check is made to ensure that sufficient space exists in the

10 disc 10 to accept these new frames as they are generated.

In the case of the three profiles 21, 22, 23 in Figure 2, the first frame of the output clip is identical to the first frame of the input clip,

15 because each of the profiles 21, 22, 23 starts at the origin of the profile graph. However, with the exception of the profile 22, the second frame of the output clip will not be the same as the second frame of the input clip, because the clip will be compressed

20 or expanded at this point in time and so a new output frame must be calculated by interpolation. For each frame in the output clip there will be a corresponding value along the x axis of the profile graph. Unless there happens to be 256 frames in the output clip,

25 i.e. the same as the number of points on the x axis, the corresponding position of each frame on the x axis must be calculated. Thus, the first stage of the interpolating process consists of identifying the position of an output frame with respect to the values

30 of the x axis. This calculated position may be an integer or it may be a fraction. If the position is an integer then the x value for the position is used to address the corresponding value in the look-up table and the corresponding y value is thus obtained.

35 If however, the calculated position is a fraction, for

example 3.5, the two locations, i.e. addresses 3 and 4, are addressed and two y values are obtained. The corresponding y value for the fraction at x value is then obtained by interpolating between the two y
5 values output from the look-up tablet which gives y as a fractional number between 1 and 256. For a given value on the y axis there will be a corresponding frame position in the input video clip. The corresponding input frame position is calculated from
10 the y value to identify the frame or frames in the input clip which is or are to comprise an output frame. The calculated input frame position may be an integer in which case a single input frame forms the output frame, ir it may be a fraction in which case
15 two input frames will contribute to the output frame. If the calculated frame position is a fraction then an interpolated output frame is derived from two stored input frames by linear interpolation of each pixel of the stored input frames using a weighting determined
20 by the fractional component of the calculated input frame position.

The process for generating new frames by interpolation will now be described by way of example with reference to Figure 3 of the accompanying
25 drawings, which shows a portion 27 of the profile 23 on an enlarged scale. Also shown in Figure 3 are axes representing output and input frame positions in relation the x and y axes respectively. In this example, a 300 frame output clip (corresponding to 10
30 seconds of NTSC video) is generated from a 200 frame input clip.

The profile portion 27 covers x values from 41 to 47, and corresponds to a range of output frames 48 to 55 derived from input frames 100 to 106. For the
35 purpose of explanation it shall now be assumed that

the process has reached the stage where it will calculate output frame number 50.

The x axis is divided into 256 integer values representing 300 output frames and therefore the position x(50) of output frame number 50 on the x axis may be expressed as a fraction of the total number of output frames:

$$x(50) = 50/300 = 0.166$$

The x values are actually stored at intervals of 1/256 and therefore the x value xs(50) of output frame number 50 with respect to the look-up table address is:

$$xs(50) = 256 \times 0.166 = 42.66.$$

The address 42.66 is not a true (i.e integer) address in the look-up table and the y value for this fractional x value is obtained by interpolating between x = 42 and x =43. From the look-up table, y = 129 when x = 42, and y = 131 when x = 43. Therefore, the y value for output frame 50, y(50), is given by:

$$y(50) = 0.66 \times 131 + (1 - 0.66) \times 129$$
$$= 86.46 + 43.86$$
$$= 130.32$$

The y axis is also divided into 256 values and represents an input clip having 200 frames. Therefore the input frame number I(50), from which output frame number 50 will be derived, is given by:

$$I(50) = 200 \times (130.32/256)$$
$$= 101.81$$

Thus, output frame number 50 is derived from input frame numbers 101 and 102 and the fractional part of I(50), i.e. 0.81, gives the weighting factor, i.e. an 81% contribution from each pixel in frame number 102 and a 19% contribution from each pixel frame number 101 on a pixel-by-pixel basis.

The output frame number 50 is thus generated by

combining frames 101 and 102 of the input clip on a pixel-by-pixel basis for each luminance and colour difference signal.

Thus, each pixel P in the output frame number 50 is calculated from:

P(OUTPUT 50) = 0.81P(INPUT 102) + 0.19P(INPUT 101) and the new frame data thus calculated is stored in the disc store 10. The process is then repeated for output frame 51 and so on until the complete output video clip of 300 frames has been generated.

All of the output frames are stored in the disc store 10 and can be read therefrom for display on the monitor 13 for review or they can be read for storage of the output clip off-line in a bulk recording device such as VTR 11.

Having thus described the present invention by reference to a preferred embodiment it is to be well understood that the embodiment in question is exemplary only and that modifications and variations such as will occur to those possessed of appropriate knowledge and skills may be made without departure from the spirit and scope of the invention as set forth in the appended claims and equivalents thereof.

CLAIMS:

1.   A video processing system, comprising a video storage device for storing an input sequence of video frames; defining means for defining an output sequence of video frames in relation to said input sequence frames; and generating means for generating an output sequence of video frames from said input video frames in accordance with the defined relationship.

2.   A video processing system as claimed in claim 1, wherein said storage device comprises a disc store for storing said input video frames and for storing output video frames generated by said generating means.

3.   A video processing system as claimed in claim 1, wherein said defining means is arranged to define a start frame and an end frame in said input video frames thereby defining an input video clip from which an output video clip is generated.

4.   A video processing system as claimed in claim 1 further comprising a monitor for displaying either of or both said input sequence of video frames and said output sequence of video frames.

5.   A video processing system as claimed in claim 1, further comprising display means for displaying a graphical representation of the defined relationship.

6.   A video processing system as claimed in claim 5, wherein said display means is arranged to display substantially orthogonal axes representing input frame

numbers and output frame numbers and to display a graph plotted against said axes representing the defined relationship.

7. A video processing system as claimed in claim 1, wherein said generating means is arranged to interpolate a pixel-by-pixel basis on two input frames to produce an output frame.

8. A video processing system as claimed in claim 1, further comprising manually operable means for use in defining said relationship.

9. A video processing system as claimed in claim 8, wherein said operable means comprises a stylus and touch tablet combination arranged to generate co-ordinate data relating to the position of the stylus on the touch tablet, which co-ordinate data is interpreted as identifying input and output video frames.

10. A video processing system as claimed in claim 1, further comprising storing means for storing discrete values defining said relationship and interpolating means for interpolating between said discrete values to obtain related values between said stored values.

11. A video processing system as claimed in claim 10, wherein said storing means comprises a random access memory device for storing said values as a look-up table.

12. A video processing system substantially as herein described with reference to the accompanying drawings.